ICH/ICH2/ICH2M Real Time Clock (RTC) Accuracy Under Environmental Stress

Application Note AP- 718

February 2001

Order Number: 292266 –003

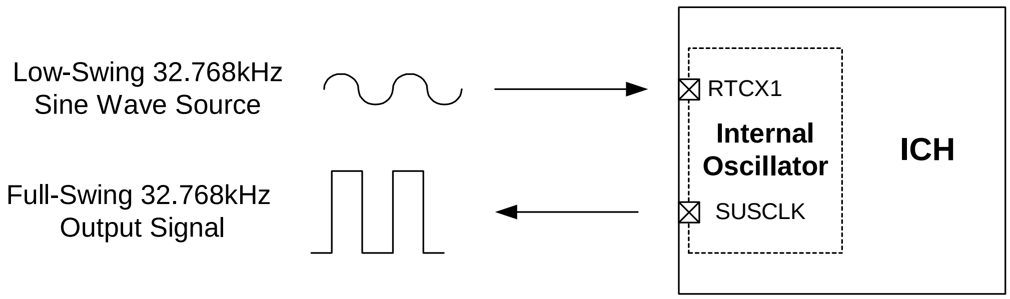
Revision History

Rev.	Draft/Changes	Date
-001	• Initial Release	Nov 2000
-002	• Revised workaround to be UL compliant	Dec 2000
-003	• Major revision including ICH2/ICH2M and humidity testing profiles	Feb 2001

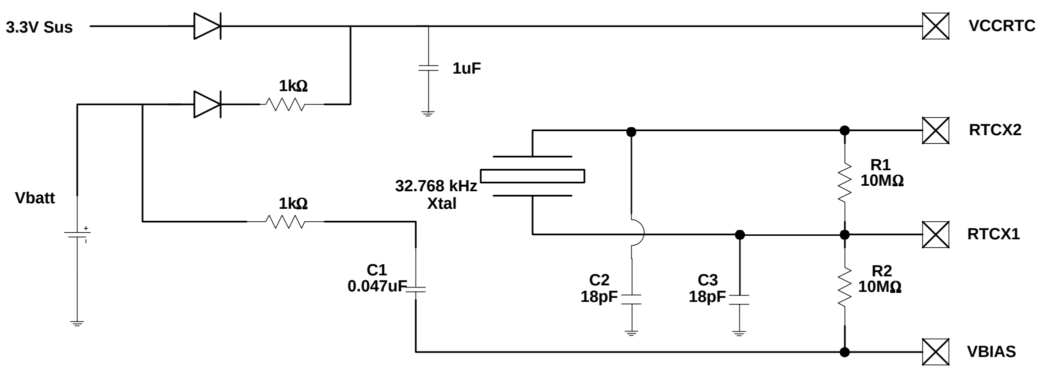
Contents

BACKGROUND – External RTC Circuit

Intel® chipsets using the 82801AA I/O Controller Hub (ICH), 82801BA I/O Controller Hub 2 (ICH2) and 82801BAM I/O Controller Hub 2 Mobile (ICH2-M) use a crystal circuit to generate a low-swing 32kHz sine wave. The crystal circuit is connected via the RTCX1 and RTCX2 pins. Internal to the ICH (ICH2/ICH2-M) this RTCX1 signal is also amplified to drive internal logic as well as generate a free running full swing clock output for system use. This output pin of the ICH is called SUSCLK and is only driven when VCC3.3SUS is applied to the ICH. This is illustrated in the following figure.



The schematic is illustrated below.



Notes
Reference Designators Arbitrarily Assigned
3.3V Sus is Active Whenever System Plugged In
Vbatt is Voltage Provided By Battery

VBIAS, VCCRTC, RTCX1, and RTCX2 are ICH pins
VBIAS is used to bias the ICH Internal Oscillator
VCCRTC powers the RTC well of the ICH
RTCX1 is the Input to the Internal Oscillator
RTCX2 is the feedback for the external crystal

The crystal network includes R1, C2, and C3 to help bias the ICH to generate the 32.768kHz sine wave. Actual values for these components are dependent on crystal component specification. VBIAS is generated by the RC network composed of R2 and C1. Filtering the 32.768kHz sine wave through this RC network produces a DC average voltage level from the sine wave to power VBIAS, which sets internal current levels. Because of the low currents in this circuit, RTCX1, RTCX2 and especially VBIAS are very sensitive to leakage.

Influences Under Environmental Stress

This ICH RTC circuit is a low current circuit designed to provide accurate time keeping service at an extremely low current consumption (ICCrtc) of approximately 2uA. As a result, this circuit is subject to adverse influences, which must be addressed or understood to ensure the best possible RTC accuracy over an environmental operating range. These influences are described below.

Crystal Characteristics: Typical 32.768 KHz crystals have an operating temperature ceiling of 60 deg. C thus limiting the test temperature accordingly. In addition, the temperature coefficient of these crystals can cause an additional time-loss of approximately 4sec/day at 60 deg. C.

Fork Capacitor Tuning: The timekeeping of the RTC is dependent on the RTCX1 input voltage swing. Insufficient swing may result in failure to meet the input switching threshold and thus “ticks” of the clock may be missed resulting in time-loss. Optimum swing on RTCX1 is achieved by accurately matching the crystal’s CLOAD specification (typically 12pF).

Board Leakage: Since this circuit operates at such low current, it is very sensitive to sources of leakage on the motherboard. Manufacturing residue can cause this leakage as well as condensation on the board encountered during temperature and/or humidity testing.

Timekeeping Baseline Device: Time of motherboards is typically compared to a baseline device, like a watch or other baseline clock device believed to be accurate. The case is that most timekeeping devices like this are not sufficiently accurate. This can cause a measurement error.

Optimizations For Stress Testing

To obtain the best RTC accuracy in environmental stress conditions the above listed factors can be optimized. While there is little that can be done to change crystal characteristics, there are opportunities to maximize the oscillator voltage swing and to minimize board leakage, described below.

Fork Capacitor Tuning: The fork capacitors (C2/C3) must be choosen to provide the greatest voltage swing (Vpp) (of RTCX1) yet still providing the best accuracy. This is typically accomplished by laboratory analysis and is specific to each motherboard. Analysis of several motherboards has shown that 18pF is optimum for many designs. This analysis is accomplished by monitoring SUSCLK accuracy with extremely sensitive measurement equipment that can measure frequency to a PPM range of less than 2 ppm. The SUSCLK output is monitored (and ICCrtc may be monitored) for various configurations of fork caps. All this can be accomplished at room/ambient conditions. The goal is the capacitor choice that provides greatest Vpp –AND- best accuracy.

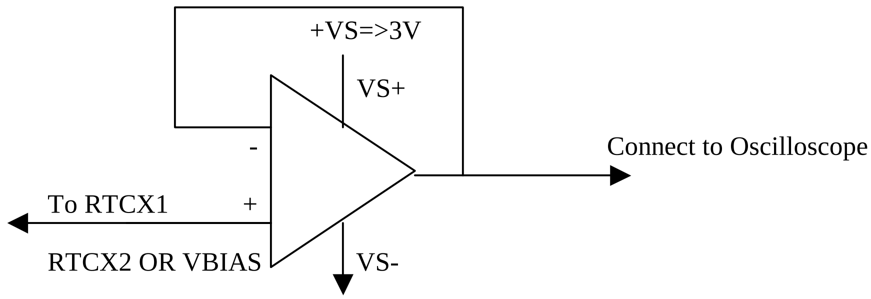
Measuring RTCX1 (RTCX2 or VBIAS) is accomplished only by using the following technique to minimize any measurement equipment loading effects. SUSCLK may be probed directly.

A) Configure an Analog Devices AD822 (AD822AR-3V) or equivalent operational amplifier (op amp) with very high input impedance (on the order of 10E12 - 10E14 ohms), as a unity gain follower as shown below. Note this may be different depending on the op amp used.

B) The conductor between the signal being measured and the op amp input must be less than 4mm with a direct connection preferable. The VS+ must be connected to a voltage source that is on all the time, such as an external supply or a 9V battery.

C) Collect the RTC electrical characteristics:

Place an oscilloscope probe with sufficient ground reference on the op amp output. The oscilloscope should be configured for 100mV/DIV and 20uS/div with trigger set to approximately 200mV, or until capture is obtained. Record the RTCX1 peak-to-peak voltage (Vpp). Optional data can be captured for DC Offset of RTCX1 & RTCX2, Vpp of XTAL2, DC level for VBIAS, and ICCrtc.



AD822AR-3V Op-Amp configured for "unity gain"

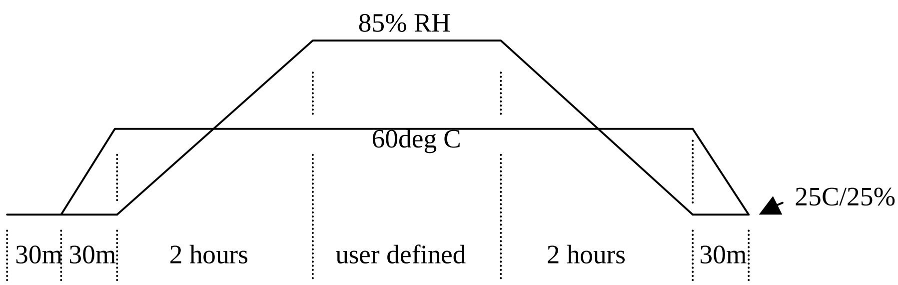
Board Leakage: Care must be made to ensure that there is no manufacturing residue left on the motherboard when performing environmental stress. Consider a solder paste containing less flux, which is an organic acid, which becomes conductive in moisture. Make sure that the board gets a thorough cleaning after the solder process, especially when using water soluble fluxes. Pay careful attention to residue left underneath discrete components of the RTC circuit and the ICH BGA.

Another source of leakage is condensation that may occur on the motherboard during environmental stress. This must be prevented. Choice of a non-condensing chamber profile can ensure that dew points are not encountered. An acceptable profile is listed below showing both temperature and relative humidity (%RH) requirements. There must be sufficient airflow in the chamber to prevent temperature spots, which could also cause condensation. The key to preventing condensation is not allowing temperature to ramp when the board is exposed to humidity. As the air temperature rises, while there is moisture in the air, the board will always be cooler than the air temperature thereby causing condensation.

Non-Condensing Temperature/Humidity Profile

1. Soak @ ambient (25 deg. C/25%RH) for 30 minutes.
2. Ramp temperature at a constant rate to a maximum of 60C over at least 30 minutes while maintaining 25%RH.
3. Ramp up %RH at a constant rate to a maximum of 85% over at least 2 hours while maintaining temperature set in step 2.
4. Soak at sustained temp/RH for user defined time.
5. Ramp down %RH at a constant rate to 25% over at least 2 hours while maintaining temperature set in step 2.
6. Ramp down temperature at a constant rate to 25C over at least 30 minutes while maintaining 25% RH.
7. Jump back to Step 1 n times.

Non-Condensing Temperature/Humidity Profile



Timekeeping Baseline Device: Accuracy of the baseline device is crucial to determining RTC accuracy. The use of watches or clocks is not sufficiently accurate for 25 ppm range accuracy over the periods used during these tests. It is required that a Global Positioning System device (GPS) be used instead. A GPS contains a clock that is reset at acquisition time to an extremely accurate time. Over time though the GPS time will drift like any other clock. For this reason the GPS should be reset, powered on outside within 15 minutes of either setting time on motherboard, or using it for a readout.

Conclusion

The occurrence of time-loss under environmental stress conditions is dependent on motherboard factors (cleanliness, discrete component characteristics, layout, fork capacitor values), and condensation. If time-loss is observed on your system, check all of the sources of inaccuracy listed above to improve immunity of the internal ICH/ICH2/ICH2-M oscillator to time loss.